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(54) Telephone or data switching system with variable protocol inter-office communication

(57) A method of producing interoffice signalling comprising storing program blocks for commanding generation, in a plurality of signalling protocols, of signalling signals in a communication switching system, storing correlations of particular ones of the program blocks with a particular protocol for signalling functions related to the process of a call to or from the communication switching system, enabling operation of the particular ones of the program blocks when a particular signalling signal is to be generated in the processing of a telephone call to or from the communication switching system, to match the particular protocol, whereby the communication switching system is enabled to process calls restricted to the particular protocol out of the plurality of protocols for a particular call.

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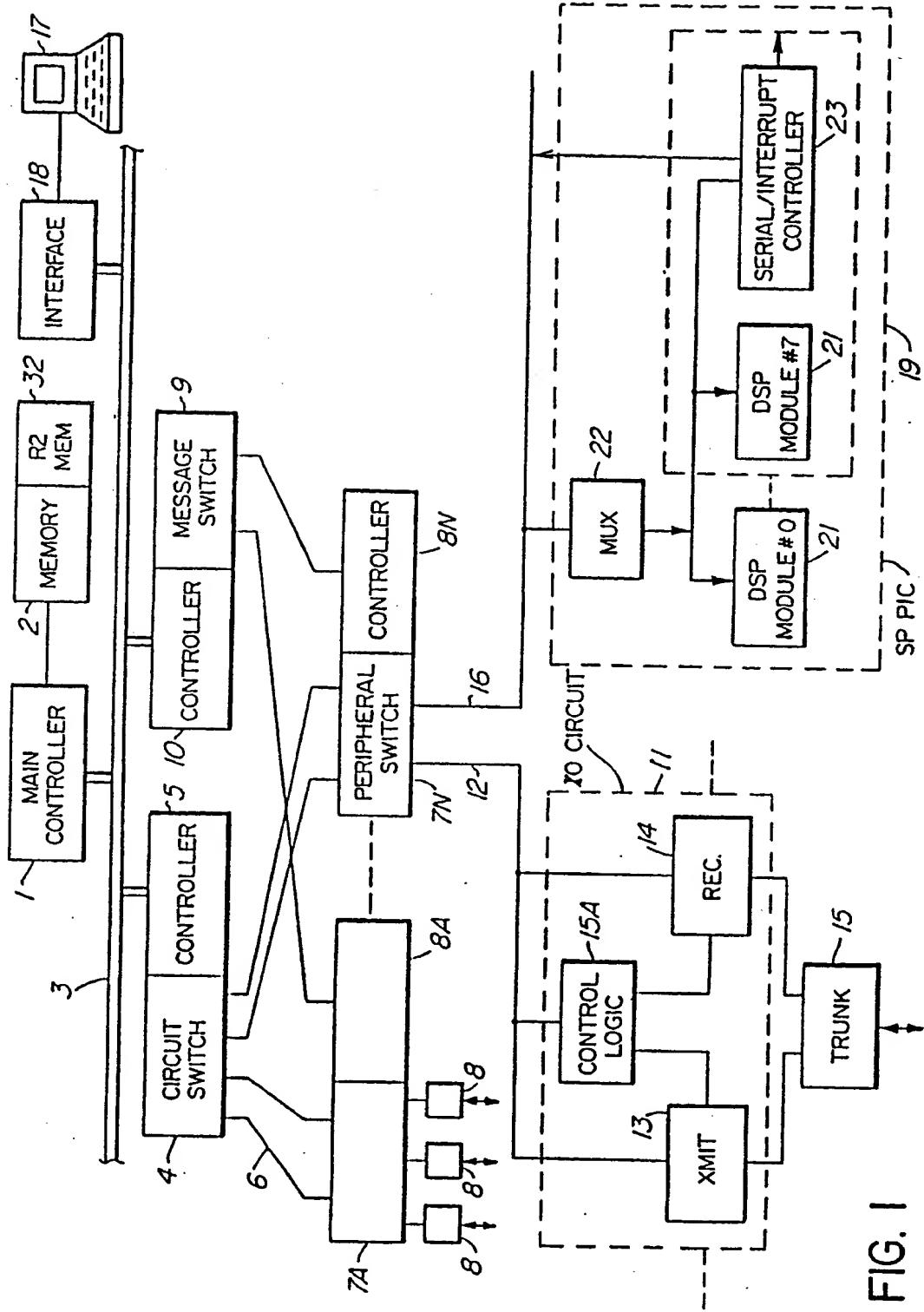


FIG. I

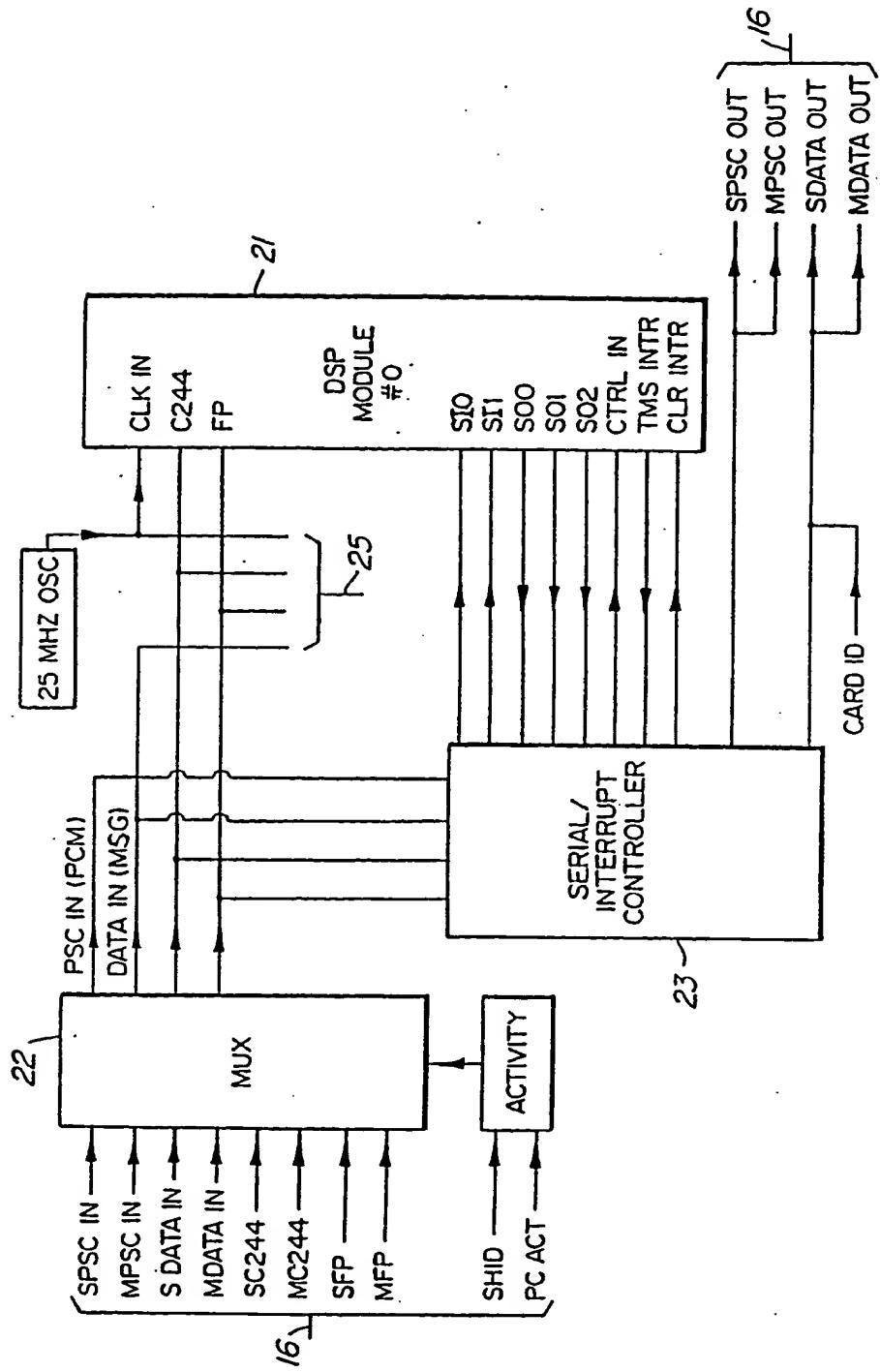


FIG. 2

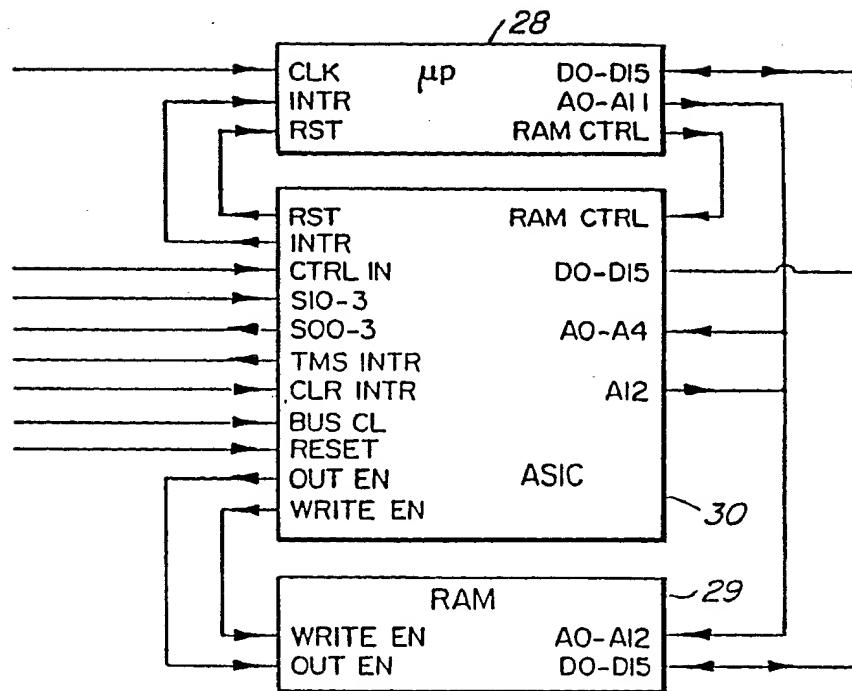


FIG. 3

R2 SIGNAL STATE ASSIGNMENT				
REMARKS: TYPE (INCOMING/OUTGOING):				
SIGNAL RECEIVED	RESPONSE TO SIGNAL		NEXT STATE	
	FIRST PROCEDURE	SECOND PROCEDURE	NO.	REMARKS
1				/ / / / / / / / / / / / / / / /
2				/ / / / / / / / / / / / / / / /
3				/ / / / / / / / / / / / / / / /
4				/ / / / / / / / / / / / / / / /
5				/ / / / / / / / / / / / / / / /
6				/ / / / / / / / / / / / / / / /
7				/ / / / / / / / / / / / / / / /
8				/ / / / / / / / / / / / / / / /
9				/ / / / / / / / / / / / / / / /
10				/ / / / / / / / / / / / / / / /
11				/ / / / / / / / / / / / / / / /
12				/ / / / / / / / / / / / / / / /
13				/ / / / / / / / / / / / / / / /
14				/ / / / / / / / / / / / / / / /
15				/ / / / / / / / / / / / / / / /

FIG. 4

R2 VARIANT ASSIGNMENT

OUTGOING REGISTER PARAMETERS

Initial outgoing procedure : send_first_digit
 Initial outgoing state . . . : Remarks : //////////////

Calling Party Category Signals (1-15)

Coin collecting box. : .
 Data transmission. : .
 Operator trunk : .
 Ordinary subscriber. : .
 Subscriber with priority . . : .
 Test equipment : .

Exception Handling

CLI not available (1-15) . . : Next state : Remarks : ///////////////
 No more CLI digits (1-15) . . : Next state : Remarks : ///////////////
 No more digits (1-15) . . . : Next state : Remarks : ///////////////

Outgoing Tone-On Timeout (1-60 seconds) . . : 15
 Outgoing Tone-Off Timeout (1-60 seconds) . . : 30

INCOMING REGISTER PARAMETERS

Initial incoming state : Remarks : //////////////

Digit Processing Request Signals (1-15)

Send next digit. : .
 Send first digit : .
 Send last digit. : .
 Send last but 1. : .
 Send last but 2. : .
 Send last but 3. : .

Digit Processing Complete Handling

Called party status transfer mechanism
 (CCITT, Immediate, None) : CCITT
 Charge/setup speech (1-15) : .
 Congestion/no switch (1-15) : .
 Get caller category (1-15) : Next state : Remarks : ///////////////

Called Party Status Signals (1-15)

Access violation : .
 Busy : .
 Congestion : .
 DID trunk congestion . . . : .
 DN in a parked state . . . : .
 DN out of service. : .
 Free, charge : .
 Free, no charge. : .
 Routed to intercept or RAD : .
 Unassigned number. : .
 User-defined exception 1 . : .
 User-defined exception 2 . : .
 User-defined exception 3 . : .

Delay before starting pulsed signal (60-240 ms, 30 ms steps) . . : 150
 Pulsed signal duration (90-900 ms, 30 ms steps) : 150
 Pulsed signal receiver reconnect delay (90-900 ms, 30 ms steps) : 300
 Pulsed return signal for first/inter-signal timer expiry (1-15) :

Figure 5

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TELEPHONE OR DATA SWITCHING SYSTEM WITH VARIABLE PROTOCOL
INTER-OFFICE COMMUNICATION

01
02 This invention relates to a telephone or
03 data signal switching system and particularly to one
04 which contains an adaptable protocol facility to
05 provide different variants of an inter-office
06 signalling protocol, such as R2 signalling, and to a
07 method of providing the protocol.

08 R2 signalling is a form of inter-switching
09 office signalling which has been standardized by
10 CCITT. This type of signalling uses dual tone
11 multi-frequency (MF) signals, and is referred to as
12 "compelled". In R2 signalling, an outgoing register
13 of an originating switching office sends a first
14 forward MF inter-register signal which is detected and
15 recognized at a receiving office, which can be at the
16 far end of a sequence of tandem switching offices.
17 Upon recognizing the first forward inter-register
18 signal, the receiving office sends a backward
19 inter-register MF signal to the originating office,
20 which has its own meaning and at the same time serves
21 as an acknowledgment. This backward inter-register
22 signal is detected and recognized at the originating
23 office whereupon it sends the next forward
24 inter-register signal to the receiving office. Again
25 the receiving office sends a next backward
26 inter-register signal to the originating office, and
27 the back and forth communication continues until the
28 last inter-register signal has been sent. The
29 communication between switching offices is conducted
30 between an outgoing register of the originating
31 central office, via a trunk, to a similar incoming
32 register at the receiving central office.

33 The system of communication is referred to
34 as "compelled" because the originating switching
35 office transmits signals in response to backward
36 signals provided by the receiving switching office.
37 The compelled nature of the protocol gives the R2 form
38 of signalling significant flexibility. This includes

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02 not only the ability to transmit a variety of
03 information, such as address signals, congestion
04 signals, calling and called party status signals,
05 etc., but also the ability to work end-to-end.
06 End-to-end signalling is the ability to communicate
07 directly with a far end incoming register, even if
08 several intervening central offices have been used to
09 route the call.

10 While the CCITT standard is usually used
11 between international switching exchanges, numerous
12 variants have been created for national use. Some of
13 those variants have little in common with the CCITT R2
14 protocol except for the signalling frequencies used.

15 The fact that various variants of the
16 standard have been implemented by various countries
17 has resulted in local national switching offices that
18 must be provided uniquely programmed to implement the
19 local national protocol. Since most modern switching
20 offices are program controlled, should changes be
21 required to the switching office due to a change in
22 national protocol or due to the switch being moved,
23 etc., new switching office computer programs are
24 required to be resident in the switching office.
25 Typically, these programs are supplied on EPROM,
26 floppy disk or magnetic tape and are supplied in each
27 instance by the switching system supplier which is
28 totally familiar with the programming requirements of
29 its switching system product.

30 Changing or updating of a switching office
31 due to a change in the inter-office communications
32 protocol requires, however, significant programming
33 effort on at least a country by country and switching
34 system by switching system basis, which is costly to
35 the customer and time consuming for the supplier.

36 In addition, with the expansion of world
37 trade in switching systems, it is desirable for a
38 switching system supplier to be able to provide a

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02 single switching system that can be easily adapted to
03 provide and receive a large variety of inter-office
04 signalling protocols or all variants of a standard
05 signalling protocol at minimum cost. Until the
06 present invention, this has not been achievable at a
07 significantly low cost and with as much ease as is
08 possible using the present invention.

09 In an embodiment to be described there is stored
10 at each switching office a plurality of program
11 procedures, referred to herein as program building
12 blocks, for implementing different portions of a
13 variety of signalling protocols for a signalling
14 standard that is to be used, such as R2. In other
15 words, small specialized control programs for
16 controlling the signalling signal to be transmitted,
17 which can be used to control the form of every
18 different possible signal that is to be transmitted,
19 are stored at the switching office. After
20 installation of the switching office, the customer, by
21 means of an user interface which is easy to use (e.g.
22 by means of a form displayed on a terminal screen),
23 selects the form of signal for each kind of signal to
24 be transmitted using the local national protocol. The
25 switching office personnel (or customer) thereby
26 designate the corresponding program building blocks.
27 The designating codes are downloaded to the control
28 memories of the portions of the switching office that
29 are to control the signalling protocol. Once
30 downloaded and resident, the switching office uses
31 corresponding building block control procedures
32 designated by the designating codes in the control
33 memories to control the form of the signalling into
34 the designated protocol.

35 A similar function is provided for
36 controlling the reception of, and interpretation of
37 signals received from the distant office in the same
38 protocol, from the trunk.

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02 As a result the switching office
03 manufacturer is no longer obliged to customize the
04 switching system inter-office signalling for each
05 national market. The customer himself designates the
06 from signalling signals required to implement the
07 protocol, and the resulting corresponding program
08 procedures which are already resident in the machine
09 automatically modify the switching office to cause the
10 signalling protocol to be implemented. This provides
11 great flexibility and saves considerable time and
12 money on the part of the customer upon initial
13 installation of the switching system and with a
14 requirement to change the signalling protocol.

15 The result is a more easy to install and
16 implement switching office which provides reduced cost
17 to the customer, increased flexibility, a saving in
18 manpower for the switching system supplier, and an
19 universal switching office that can be sold for use in
20 all markets which use variants of the same standard
21 signalling protocol: in the case of CCITT R2
22 signalling, this includes most countries of the world.

23 One embodiment of the invention is a
24 method of producing interoffice signalling comprising
25 storing program blocks for commanding generation, in a
26 plurality of signalling protocols of signalling
27 signals in a communication switching system, storing
28 correlations of particular ones of the program blocks
29 with a particular protocol for signalling functions
30 related to the process of a call to or from the
31 communication switching system, enabling operation of
32 the particular ones of the program blocks when a
33 particular signalling signal is to be generated in the
34 processing of a telephone call to or from the
35 communication switching system, to match the
36 particular protocol, whereby the communication
37 switching system is enabled to process calls
38 restricted to the particular protocol out of the

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02 plurality of protocols for a particular call.

03 Another embodiment of the invention is a
04 communication switching system comprising signal
05 generating apparatus for generating interoffice
06 signalling signals, at least one trunk for
07 transmitting the signalling signals, apparatus for
08 connecting the signal generating apparatus to the
09 trunk, apparatus for storing a plurality of program
10 blocks for commanding generation of the signalling
11 signals according to a plurality of protocols,
12 apparatus for storing designations of particular ones
13 of the program blocks to command operation of the
14 signal generating apparatus in accordance with a
15 particular predetermined protocol, apparatus for
16 enabling the particular ones of the program blocks
17 during the processing of a call to or from another
18 switching office, whereby communication therewith in
19 accordance with the particular predetermined protocol
20 is mandated.

21 While reference to the invention being
22 implemented on a switching office is made throughout
23 this specification, it should be noted that the
24 invention can be implemented on suitable PABXs, and
25 therefore reference to switching offices (switching
26 systems) throughout this specification should be
27 construed to include such PABXs. The invention can be
28 used equally in analog and digital systems, and in
29 types used to transmit analog voice, digital (PCM)
30 voice, or data signals.

31 A better understanding of the invention
32 will be obtained by reference to the detailed
33 description below, with reference to the following
34 drawings, in which:

35 Figure 1 is a block diagram of a switching
36 system utilizing the present invention,

37 Figure 2 is a block diagram of a signal
38 processor peripheral interface circuit used as part of

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02 the invention,

03 Figure 3 is a block diagram of a digital
04 signal processor module used in the signal processor
05 of the invention,

06 Figure 4 is a first terminal screen form
07 used in an embodiment of the invention, and

08 Figure 5 is a second terminal screen form
09 used in an embodiment of the invention.

10 Refer now to Figure 1, which illustrates a
11 basic block diagram of a switching system such as one
12 sold by Mitel Corporation under the trade mark
13 GX5000™ implementing the present invention.

14 The switching system is formed of a main
15 controller 1 to which memory 2 is connected, and a
16 main parallel bus 3 to which the main controller is
17 connected. A circuit switch 4 controlled by a
18 controller 5 which is connected to the bus 3, switches
19 pulse code modulated (PCM) signals via lines 6 to
20 inputs of peripheral switches 7A-7N, to which
21 peripherals such as line circuits and trunk circuits 8
22 are connected. The controllers 1, 5 and 10 can be
23 implemented in a single controller. Peripheral
24 switches 7A-7N are controlled by peripheral
25 controllers 8A-8N. Control signals from main
26 controller 1 are switched to controllers 8A-8N by
27 means of a message switch 9 which is controlled by
28 controller 10, connected to bus 3 for receiving
29 control messages from main controller 1. The switches
30 are combination time and space division switches, as
31 described in U.S. Patent 4,510,597 issued
32 April 9th, 1985 assigned to Mitel Corporation and
33 entitled "TIME DIVISION SWITCHING MATRIX".

34 Programs to control operation of this
35 system are stored in memory 2, and are accessed by
36 main controller 1.

37 In order to effect R2 inter-office
38 signalling, input-output (I/O) circuits such as

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02 circuit 11 are connected to peripheral switch 7N.
03 Each I/O circuit 11 is connected to an I/O bus 12,
04 which is connected to peripheral switch 7N. I/O
05 circuit 11 is formed of a transmitter 13 and a
06 receiver 14 for respectively transmitting and
07 receiving signalling signals respectively to and from
08 an inter-office trunk 15. The transmitter and
09 receiver are controlled by control logic 15A.

10

Another I/O bus 16 is connected to
11 peripheral switch 7N. Communications may be made
12 between different peripherals via peripheral switch
13 7N, and via switch 7N, switch 4, switch 7A and between
14 peripherals connected to the various peripheral
15 switches 7A-7N. It should also be noted that message
16 (control) signals may be applied to any peripheral
17 from controllers 8A-8N due to their connection to
18 peripheral switches 7A-7N internally. Thus, for
19 example, a message may be transmitted from main
20 controller 1 through bus 3, controller 10, message
21 switch 9 to peripheral controller 8N. Controller 8N
22 in response can control control logic 15 through
23 switch 7N, for controlling either or both of
24 transmitter 13 and receiver 14 connected to trunk 15.

25

A system similar to that described above
26 is described in more detail in the following patents:
27 U.S. Patent 4,510,597 issued April 9th, 1985 entitled
28 "Time Division Switching Matrix"; U.S. Patent
29 4,615,028 issued September 30th, 1986 entitled
30 "Switching System with Separate Supervisory Links" and
31 U.S. Patent 4,685,102 issued August 4th, 1987 entitled
32 "Switching System Loopback Test Circuit". The content
33 of the aforesigned three patents is incorporated herein
34 by reference.

35

As this form of switching system is under
36 stored program control, diagnostic and communication
37 with the system by a technician is made via a computer
38 terminal 17 which is connected to a bus interface 18

02 of conventional form, which itself is connected to the
03 main parallel bus 3.

04 In accordance with the present embodiment a
05 digital signal processor peripheral interface circuit
06 (SP PIC) 19 is connected to bus 16. Each SP PIC
07 occupies, in a successful prototype, one slot in a
08 peripheral switch rack-mounted shelf, and contains
09 eight signal processing modules 21, referenced DSP
10 module #0 - DSP module #7 in Figure 1. Each DSP
11 module is connected to the output of a multiplexer 22,
12 which interfaces the I/O bus 16 and to a
13 serial/interrupt controller 23. Controller 23 and the
14 DSP modules can be connected together and combined
15 with MUX 22 by connecting the DSP modules 21 and
16 controller 23 to bus 16 via a switching matrix as
17 described in the aforenoted patents.

18 Figure 2 illustrates a more detailed block
19 diagram of the signal processor PIC. The peripheral
20 bus 16 is connected to the input of multiplexer 22.
21 The output of multiplexer 22 is a serial PCM line PCS
22 IN which is connected to the input of serial/interrupt
23 controller 23. A serial message line DATA IN is
24 connected from the output of multiplexer 22 to
25 serial/interrupt controller 23. In addition clock and
26 frame pulse signals are applied from the output of
27 multiplexer 22 to the input of controller 23. The
28 latter are also applied to corresponding inputs of
29 illustrated DSP module #0, 21.

30 * Serial input lines SI0 and SI1 are
31 connected from controller 23 to corresponding inputs
32 of DSP module 21, with control in CTRIN and clear
33 interrupt CLRINTR lines. Output serial lines from DSP
34 module 21 SO0, SO1 and SO2 are connected to controller
35 23, along with a TMSINTR line.

36 Output lines from controller 23 are serial
37 SPSC OUT and MPSC OUT, and serial data lines SDTA OUT
38 and MDTA OUT which are connected to bus 16, and thus

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02 to peripheral switch 7N. SPSC IN and SPSC OUT are the
03 same plane PCM paths (i.e. they are connected to the
04 peripheral controller/matrix residing in the same
05 shelf). MPSC IN and MPSC OUT are connected to the
06 mate plane controller. SDATA OUT and MDATA OUT carry
07 message information via bus 16 to peripheral switch 7N.

08 The data in, C244, FP and clock lines are
09 connected to data bus 25 (see Figure 1). That bus is
10 connected to another serial/interrupt controller.
11 associated with DSP module #1. In this manner,
12 several DSP modules can be connected with an
13 associated controller to the serial output of
14 multiplexer 22.

15 Figure 3 illustrates a preferred form of
16 the DSP module. The module is controlled by a
17 controller 28, which preferably is formed of a
18 microprocessor such as Texas Instruments type
19 TMS32010. Connected to the controller 28 is a random
20 access memory RAM 29 having 16K bytes. An ASIC 30 is
21 connected to RAM 29 and controller 28.

22 The structure of the ASIC should perform
23 the following functions: It should allow the
24 microprocessor 28 to be controlled via a serial bus
25 link. It should support a host interface bound
26 interrupt from the controller 28. It should provide
27 an interface between the controller parallel bus and
28 the serial bus. It should support a host interface
29 controlled interrupt sequence for the controller 28.
30 This interrupt sequence should be synchronized to the
31 serial bus. It should contain a boot strap program
32 required to download applications program code from
33 the peripheral switch controller 8N into the memory
34 29. Finally, it should control the memory 29 page
35 address bit.

36 The CTRLIN signal to the ASIC is a serial
37 link signal. Each channel on the link should contain
38 a command byte which is decoded and executed by the

02 DSP module. The ASIC executes the command byte during
03 the channel time which follows the channel on which
04 the command byte is received.

05 The serial/interrupt controller 23 is
06 implemented using an array of time division/space
07 division switches, such as described in U.S. Patent
08 4,510,597. Each of those devices provides a serial
09 control for a pair of DSP modules.

10 The system in general operates as
11 follows. Memories associated with controllers 8A-8N
12 each contain all building block program procedures for
13 implementing different portions of a variety of
14 inter-office trunk protocols for each possible signal
15 to be transmitted. Memory 2 is partitioned to contain
16 in partitioned portion 32 a program of well known form
17 which allows data input charts to be displayed on the
18 screen of computer terminal 17, correlating received
19 signals versus functions to be performed.

20 Each of the DSP modules contain a
21 functionally simple non-customizable program which
22 transmits and receives the MF-R2 signals, the
23 frequencies and levels of the tones thereof having
24 been specified in the CCITT standard.

25 After installation of the main switching
26 system and loading of the DSP modules, the customer
27 technician (operator) accesses main controller 1 by
28 terminal 17 through interface 18 and bus 3, which
29 brings from memory 32 a first chart on the screen of
30 the terminal such as the one shown in Figure 4.

31 The operator defines the various
32 functional aspects using a predetermined set of user
33 codewords for each signal. Once all the aspects have
34 been defined, the main controller 1 downloads the user
35 defined codewords to peripheral controller 8N
36 designating the particular program building blocks to
37 be used, for particular signals, where the correlation
38 is stored. The user defined codewords are downloaded

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02 by controller 1 through controller 10 and message
03 switch 9 to the peripheral switch controller 8N, where
04 the full complement of program building blocks are
05 stored, and resident in the control memories of
06 peripheral switches 7A-7N. The selected building
07 blocks then control the various switches and modules
08 to control the form of the signals output on the
09 various inter-office trunks, in accordance with the
10 local variant of the R2 protocol.

11 In operation, controller 8N commands using
12 the designated correlated command that e.g. DSP module
13 21 should transmit a signal, by writing into channels
14 on the message link on bus 16 via peripheral switch
15 7N. A link is set up via switch 7N to a trunk 15.
16 From bus 16, the command is routed along the SDATAIN
17 or MDATAIN leads through MUX 22 and serial/interrupt
18 controller 23 into the DSP module on lead S10 where it
19 is read by the DSP program which is running there. A
20 resulting tone signal in PCM is generated which is
21 passed via bus 16 through switch 7N to bus 12 and is
22 transmitted via transmitter 13 to trunk 15.

23 Controller 8N is notified that a response
24 tone has been detected or received, by the DSP module
25 writing into channels on the S00 lead which are via
26 serial/interrupt controller 23 to the SDATAOUT and
27 MDATAOUT leads on bus 16.

28 It should be noted that once the PCM
29 connection is set up between the trunk 15 and a DSP
30 module via a switch 7N, MF-R2 signalling takes place
31 in-band. That is, the trunk control logic 15 does not
32 interact with the R2 protocol. At this point, the
33 trunk card is just carrying what it considers to be
34 speech (MF-R2 signals) and so the transmitter 13 and
35 receiver 14 just perform normal digital-to-analog and
36 analog-to-digital conversions.

37 As an example, consider an outgoing trunk
38 call using MF-R2 signalling. A seize message is sent

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02 from main controller 1, via message switch 9 to
03 peripheral controller 8N requesting it to cause
04 control logic 15 to seize trunk 15. Similarly, a
05 seize message is sent from main controller 1 to
06 peripheral controller 8N requesting it to schedule the
07 R2 register control program which is resident in its
08 memory. A PCM connection is set up from the DSP
09 module 21 to the trunk's transmitter 13 via peripheral
10 switch 7N, circuit switch 4 and peripheral switch 7N.
11 Similarly a connection is set up via the same
12 switching matrices between the trunk's receiver 14 and
13 the DSP module 21.

14 The R2 register control program running on
15 peripheral controller 8N now causes DSP module 21 to
16 transmit the first forward signal as specified by the
17 downloaded codewords. It does this by sending a
18 message via bus 16 to DSP module 21 (as described
19 above).

20 When a response signal is received from
21 the far end trunk by DSP module 21, it notifies the R2
22 register control program resident at peripheral
23 controller 8N by sending a message via bus 16. Upon
24 receiving this message, the R2 register control
25 program determines a signal to send in response using
26 the downloaded codewords and the sequence described
27 above is repeated.

28 This process continues until the protocol
29 is completed. At this time, the PCM connections to
30 the DSP module are broken and MF-R2 signalling is
31 complete.

32 Figure 4 illustrates a form that can be
33 used on the terminal 17 as an aid for the customer
34 technician to characterize the signalling for one
35 category of signals used in the protocol. In the
36 left-hand column are numbers of the fifteen different
37 signals, put up on the terminal 17 screen by
38 controller 1, and in the second and third columns, the

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02 action to be performed is entered by a technician
03 using predefined terms. Successive ones of the data
04 entry form are used for each category of signals in
05 the protocol. This form is definable only at the
06 installer level, i.e. the highest access authorization
07 level.

08 In the second and third columns, up to two
09 action responses can be entered. If both are
10 specified, the first is executed before the second.
11 Of course the two procedures cannot be the same. The
12 system action responses can be selected from building
13 block procedures described below.

14 At the top of the form, it is entered
15 whether the form is being used for incoming or
16 outgoing signals.

17 In the list of program building blocks
18 listed below, each action is defined by a first word
19 forming the language, followed by the function to be
20 implemented by the system in response.

Outgoing State Building Blocks

Procedures which can be executed in the context of an outgoing R2 register are listed below. If the procedure might be executed in response to a standard CCITT signal, that signal is listed beside the procedure.

CCITT Standard	Name of Procedure / Description
---	connect Release the MF-R2 transceiver and connect the speech path. Set up the appropriate charging mechanism if required.
A-4, 15 B-4	excep_congestion Set the R2 exception to congestion.
B-8	excep_dn_out_of_serv Set the R2 exception to DN out of service.
---	excep_invalid_signal Set the R2 exception to invalid signal.
---	excep_none Set the R2 exception to none (default).
B-3	excep_sub_busy Set the R2 exception to busy.
B-5	excep_unassigned_num Set the R2 exception to unassigned number.
---	excep_user_1 Set the R2 exception to user-defined exception number 1.
---	excep_user_2 Set the R2 exception to user-defined exception number 2.
---	excep_user_3 Set the R2 exception to user-defined exception number 3.
---	reroute Terminate the current call and attempt alternative rerouting.

CCITT Standard	Name of Procedure / Description
---	reset_CLI_index Set the next CLI digit index to the beginning of the CLI number.
---	reset_digit_index Set the next digit index to the beginning of the number.
A-3 A-5	send_category Send category of calling party. This procedure sends the category programmed in the class of service, using the mapping given in the R2 Variant Assignment.
---	send_first_CLI_digit Send the first calling line identification digit. If no CLI is available, the exception handling specified in the R2 Variant Assignment is used.
---	send_first_digit Restart.
A-2	send_last_but_1 Send digit (n-1).
A-7	send_last_but_2 Send digit (n-2).
A-8	send_last_but_3 Send digit (n-3).
---	send_last_digit Repeat last digit sent (n).
---	send_next_CLI_digit Send the next CLI digit. If no more CLI digits are available, the exception handling specified in the R2 Variant Assignment is used.
A-1	send_next_digit Send digit (n+1).

CCITT Standard	Name of Procedure / Description
---	set_called_control Mark the call as being under called party control.
---	set_calling_control Mark the call as being under calling party control.
A-6 B-6	set_chargeable Mark that the call is chargeable. This is the default condition for every new call.
---	set_first_control Mark the call as being under first party control.
---	set_joint_control Mark the call as being under joint party control.
B-7	set_not_chargeable Mark that the call is not chargeable.
---	terminate Release the MF-R2 transceiver and terminate the current call with exception handling specified by the current R2 exception.
---	send_1, send_2, send_3, send_4, send_5, send_6, send_7, send_8, send_9, send_10, send_11, send_12, send_13, send_14, send_15 Send the nth forward signal.

Incoming State Building Blocks

CCITT Standard	Name of Procedure / Description
---	category_ccb Mark the caller as a coin collecting box.
II-6	category_data Mark the caller as a data transmission.
II-5	category_operator Mark the caller as an operator.
II-1	category_ordinary Mark the caller as an ordinary subscriber.
II-2	category_priority Mark the caller as a subscriber with priority.
II-3	category_test Mark the caller as test equipment.
---	excep_invalid_signal
---	excep_none See outgoing state building blocks.
I-10	process_digit_0
I-11	process_digit_1
I-12	process_digit_2
I-13	process_digit_3
I-14	process_digit_4
I-15	process_digit_5
I-16	process_digit_6
I-17	process_digit_7
I-18	process_digit_8
I-19	process_digit_9
I-15	process_digit_timeout Use the specified digit, the digit tree and the information in the R2 Variant Assignment to attempt to route the call.
---	send_status_and_end Send the called party status. When the signalling cycle is complete, either clear down the call or connect the speech path.
---	terminate See outgoing state building blocks.
---	send_1, send_2, send_3, send_4, send_5, send_6, send_7, send_8, send_9, send_10, send_11, send_12, send_13, send_14, send_15 Send the nth backward signal.

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03 It should be noted that the particular
04 procedures specified are all procedures that are
05 normally implemented in a switching office.
06 Consequently the particular program listings are not
07 given herein, as they will be different for each form
08 of switching office and are known to persons skilled
in the art.

09

10 A representative second form which is
11 preferred to be used to define variants, that is, to
12 specify the initial procedures and conditions and time
13 outs, as well as parameters for the program building
14 block procedures, such as the mapping of logical
conditions to physical signals, is shown in Figure 5.

15

16

A list and description of each of the
fields to be identified follows:

Field Descriptions

1. Initial outgoing procedure

The initial outgoing procedure is the R2 building block procedure which should be executed when outgoing R2 signalling is initiated. This procedure is generally `send_first_digit`, but in some cases the explicit signal procedures (`send1`, `send2` etc.) may also be useful.

2. Initial outgoing state

The initial outgoing state is the state to enter after executing the initial outgoing procedure. The register stays in this state until it either receives a backward signal from the incoming register or the forward tone timeout period expires. When this form is committed, the remark programmed against the requested state is displayed in a protected field.

3. Calling party category

The data in this section are used to map the calling party category (as defined in the class of service) to a physical R2 signal to transmit when the calling party category is requested.

4. Exception handling

The signals in this section are used to respond to backward signalled requests which the outgoing R2 register cannot comply with.

(a) CLI not available

This defines the signal to return if a request for calling line identification digits has been received, but none are available (for example, on a tandem call when the incoming link does not transmit the calling party's number). If no signal is specified, none is returned. If no next state is specified, execution continues in the same state.

When this form is committed, the remark programmed against the requested state is displayed in a protected field.

This exception handling is invoked by the `send_first_CLI_digit` procedure.

(b) No more CLI digits

This defines the signal to return if a request for more CLI digits (not including the first) has been received, but none are available. If no signal is specified, none is returned. If no next state is specified, execution continues in the same state.

When this form is committed, the remark programmed against the requested state is displayed in a protected field.

This exception handling is invoked by the `send_next_CLI_digit` procedure.

(c) No more digits

This defines the signal to return if a request for more digits (not including CLI digits) has been received, but none are available. If no signal is specified, none is returned. If no next state is specified, execution continues in the same state.

When this form is committed, the remark programmed against the requested state is displayed in a protected field.

This handling is invoked by the `send_next_digit` procedure when call processing determines that the entire called number has been entered and the terminating register requests another digit. The entire called number is considered entered when critical timing has been completed or the last digit in the digits to follow programmed against the route has been received.

5. Forward tone timeout

The forward tone timeout is the maximum period for which the outgoing register will continue to transmit a forward signal in the absence of an acknowledging backward signal. It is also the maximum period for which the outgoing register will wait for a pulsed backward signal when no forward signal is being sent. If this timeout occurs, the call will be terminated. CCITT Q.476 recommends a period of 15 +/- 3 seconds.

6. No-tone timeout

The no-tone timeout is the maximum period for which the outgoing register will wait for a backward signal

to be removed after the time that the forward signal is removed. If this timeout occurs, the call will be terminated.

7. Initial incoming state

The initial incoming state is the state which the incoming register enters when it is first seized. When this form is committed, the remark programmed against the requested state is displayed in a protected field.

8. Called party status signals

The data in this section are used by the incoming register to map the called party status (as determined by call processing) to a physical R2 signal to send when the called party status is to be transmitted. More than one status may be mapped to the same physical signal. For example, if special information tone is available, access violations might be mapped to the signal to request it. If it is not available, access violations might be mapped to the same signal as directory number out of service.

9. Digit processing action table

This table maps the digit processing actions which might be required to route a call to the physical R2 signals to transmit in order to request these actions. For example, if the digit tree indicates that another digit is required, the 'Send next digit' signal is sent.

If no signal is programmed against an action, call processing will use the rules specified in Section 2.1 under Digit Processing Action Table.

At least one of the two 'address done' conditions must be programmed. When this form is committed with a next state programmed for the 'address complete, get category' field, the remark programmed against that state is displayed in a protected field.

10. Delay before starting pulsed signal

This delay is inserted between the end of transmission of the last signal of the compelled cycle and the start of transmission of the pulsed signal. It must be specified in increments of 30 ms. CCITT Q.442 recommends a minimum delay of 100 ms.

11. Pulsed signal duration

This field specifies the duration of signals sent as pulsed signals. It must be specified in increments of 30 ms. CCITT Q.442 recommends a pulsed signal duration of 150 ms.

12. Pulsed signal receiver reconnect delay

This field specifies the time, after the completion of the pulsed backward signal, before the incoming receiver can be reconnected. It is ignored in cases where the R2 register signalling is terminated after sending the pulsed signal. This delay must be specified in increments of 30 ms. CCITT Q.442 recommends a delay of 300 +/- 100 ms.

13. Pulsed return signal for first/inter-digit timer expiry

If the first digit or interdigit timers, as programmed on a trunk's class of service, expire, this field defines the signal which should be returned, in pulsed form, before the call is terminated. If no signal is specified, none is sent.

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The following illustrate filled in action identifying forms for six separate signalling conditions, in which the first represents a state of sending outgoing digits, the second of sending outgoing CLI, the third of handling the receipt of the called party status after confirmation the outgoing category has been sent, the fourth of receiving incoming digits, the fifth of terminating signalling after sending signal BJ, and the sixth of handling the receipt of the calling party category and terminating signalling after sending the called party status. The assignment noted has been created to cause performance of the R2 signalling variations of Kenya, for a switching system manufactured by Mitel Corporation designated by the trade mark GX5000. The various signal functions identified above are noted in the headnote of each form. The procedures listed correspond to the building block functions described earlier in this disclosure.

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R2 Signal State Assignment				
R2 Variant : 1	R2 State : 1	Remarks : A_Send_Dgts	Type (Incoming/Outgoing) : Outgoing	
Signal Received	First procedure	Response to Signal Second procedure	No.	Next State Remarks
////1///	send_next_digit			
////2///	send_last_but_1			
////3///	send_category			
////4///	excep_congestion			
////5///	send_category			
////6///	set_chargeable			
////7///	send_last_but_2			
////8///	send_last_but_3			
////9///	send_first_digit			
////10///	set_chargeable			
////11///	set_chargeable			
////12///	set_chargeable			
////13///	set_chargeable			
////14///	set_chargeable			
////15///	set_chargeable			
		reroute reset_CLI_index connect	3 2	//////B_Sent_Catgy//// //////A_Send_CLI////
		connect		

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R2 Signal State Assignment

R2 Variant : 1 R2 State : 2 Remarks : A_Send_CLI
Type (Incoming/Outgoing) : Outgoing

Signal Received	Response to Signal First procedure	Second procedure	No.	Next State Remarks
////1///	excep_unassigned_num	terminate		/
////2///	excep_unassigned_num	terminate		/
////3///	excep_unassigned_num	terminate		/
////4///	excep_congestion	reroute		/
////5///	send_next_CLI_digit			/
////6///	excep_unassigned_num	terminate		/
////7///	excep_unassigned_num	terminate		/
////8///	excep_unassigned_num	terminate		/
////9///	excep_unassigned_num	terminate		/
////10///	excep_unassigned_num	terminate		/
////11///	excep_unassigned_num	terminate		/
////12///	excep_unassigned_num	terminate		/
////13///	excep_unassigned_num	terminate		/
////14///	excep_unassigned_num	terminate		/
////15///	excep_unassigned_num	terminate		/

R2 Signal State Assignment

R2 Variant : 1 R2 State : 3 Remarks : B_Sent_Catgy
Type (Incoming/Outgoing) : Outgoing

Signal Received	Response to Signal First procedure	Second procedure	No.	Next State Remarks
////1///	excep_unassigned_num	terminate		/
////2///	excep_unassigned_num	terminate		/
////3///	excep_sub_busy	terminate		/
////4///	excep_congestion	reroute		/
////5///	excep_unassigned_num	terminate		/
////6///	set_chargeable	connect		/
////7///	excep_unassigned_num	terminate		/
////8///	excep_unassigned_num	terminate		/
////9///	excep_unassigned_num	terminate		/
////10///	excep_unassigned_num	terminate		/
////11///	excep_unassigned_num	terminate		/
////12///	excep_unassigned_num	terminate		/
////13///	excep_unassigned_num	terminate		/
////14///	excep_unassigned_num	terminate		/
////15///	excep_unassigned_num	terminate		/

R2 STATE ASSIGNMENT				
R2 Variant : 1 R2 State : 4		Remarks : I_Rcv_Digits Type (Incoming/Outgoing) : Incoming		
Signal Received	First procedure	Response to Signal Second procedure	Next State No.	Remarks
////1///	process_digit			
////2///	process_digit			
////3///	process_digit			
////4///	process_digit			
////5///	process_digit			
////6///	process_digit			
////7///	process_digit			
////8///	process_digit			
////9///	process_digit			
////10///	process_digit			
////11///	send3		5	/B5_Next///
////12///	send3		5	/B5_Next///
////13///	send3		5	/B5_Next///
////14///	send3		5	/B5_Next///
////15///	send3		5	/B5_Next///

R2 STATE ASSIGNMENT				
R2 Variant : 1 R2 State : 5		Remarks : B5_Next Type (Incoming/Outgoing) : Incoming		
Signal Received	First procedure	Response to Signal Second procedure	Next State No.	Remarks
////1///	send5	terminate		
////2///	send5	terminate		
////3///	send5	terminate		
////4///	send5	terminate		
////5///	send5	terminate		
////6///	send5	terminate		
////7///	send5	terminate		
////8///	send5	terminate		
////9///	send5	terminate		
////10///	send5	terminate		
////11///	send5	terminate		
////12///	send5	terminate		
////13///	send5	terminate		
////14///	send5	terminate		
////15///	send5	terminate		

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R2 STATE ASSIGNMENT

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R2 Variant : 1 R2 State : 6 Remarks : II_Catgy_Nxt
 Type (Incoming/Outgoing) : Incoming

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Signal Received	First procedure	Response to Signal Second procedure	Next State No.	Remarks
////1///	category_ordinary	connect_reply_status		//////////
////2///	category_ordinary	connect_reply_status		//////////
////3///	category_ordinary	connect_reply_status		//////////
////4///	category_ordinary	connect_reply_status		//////////
////5///	category_ordinary	connect_reply_status		//////////
////6///	category_ordinary	connect_reply_status		//////////
////7///	category_ordinary	connect_reply_status		//////////
////8///	category_ordinary	connect_reply_status		//////////
////9///	category_ordinary	connect_reply_status		//////////
////10///	category_ordinary	connect_reply_status		//////////
////11///	category_ordinary	connect_reply_status		//////////
////12///	category_ordinary	connect_reply_status		//////////
////13///	category_ordinary	connect_reply_status		//////////
////14///	category_ordinary	connect_reply_status		//////////
////15///	category_ordinary	connect_reply_status		//////////

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The associated variant assignment is shown

below.

R2 VARIANT ASSIGNMENT

R2 Variant : 1

OUTGOING REGISTER PARAMETERS

Initial outgoing procedure : send_first_digit
 Initial outgoing state . . . : 1 Remarks : A_Send_Dgts/

Calling Party Category Signals (1-15)
 Coin collecting box : 1
 Data transmission : 1
 Operator trunk : 1
 Ordinary subscriber : 1
 Subscriber with priority : 1
 Test equipment : 1

Exception Handling
 CLI not available (1-15) . . . : 15 Next state : 1 Remarks : A_Send_Dgts/
 No more CLI digits (1-15) . . . : 15 Next state : 1 Remarks : A_Send_Dgts/
 No more digits (1-15) . . . : Next state : Remarks : ////////////////

Outgoing Tone-On Timeout (1-60 seconds) . . . : 15
 Outgoing Tone-Off Timeout (1-60 seconds) . . . : 30

INCOMING REGISTER PARAMETERS

Initial incoming state : 4 Remarks : I_Rcv_Digits

Digit Processing Request Signals (1-15)
 Send next digit : 1
 Send first digit : 9
 Send last digit :
 Send last but 1 : 2
 Send last but 2 : 7
 Send last but 3 : 8

Digit Processing Complete Handling
 Called party status transfer mechanism
 (CCITT, Immediate, None) : CCITT
 Charge/setup speech (1-15) : 6
 Congestion/no switch (1-15) : 4
 Get caller category (1-15) : 3 Next state : 6 Remarks : II_Catgy_Nxt

Called Party Status Signals (1-15)
 Access violation : 5
 Busy : 3
 Congestion : 4
 DID trunk congestion : 3
 DN in a parked state : 3
 DN out of service : 5
 Free, charge : 6
 Free, no charge : 6
 Routed to Intercept or RAD : 6
 Unassigned number : 5
 User-defined exception 1 : 4
 User-defined exception 2 : 4
 User-defined exception 3 : 4

Delay before starting pulsed signal (60-240 ms, 30 ms steps) . . . : 150
 Pulsed signal duration (90-900 ms, 30 ms steps) : 150
 Pulsed signal receiver reconnect delay (90-900 ms, 30 ms steps) : 300
 Pulsed return signal for first/inter-signal timer expiry (1-15) : 4

02 It may thus be seen that with the
03 embodiment described above the customer can cause the
04 switching office to identify the building block
05 programs from the large number of available programs
06 stored in the peripheral controller memories. The
07 result is that controlling programs selected out of a
08 large number of available programs cause the system to
09 self configure so as to process inter-office
10 signalling according to the particular local variant.
11 This is done without requiring special attention by
12 the system manufacturer, and can be changed at will by
13 the customer to accommodate a change in location of
14 the switching office, to update the protocol and upon
15 installation.

16 While the embodiments described refer to
17 R2 signalling, the principles of this invention are
18 not limited for use with R2 signalling, or indeed to
19 inter-office signalling, and may be applied for
20 self-configuration of the switching system in order to
21 adapt it to any other local conditions desired.

22 A person skilled in the art understanding
23 the present invention may now conceive of variations
24 or other embodiments using the concepts described
25 herein. All are considered to be within the sphere
26 and scope of the invention as defined in the claims
27 appended hereto.

CLAIMS

1. A method of producing interoffice signalling comprising:

(a) storing program blocks for commanding generation, in a plurality of signalling protocols, of signalling signals in a communication switching system,

(b) storing correlations of particular ones of said program blocks with a particular protocol for signalling functions related to the process of a call to or from said communication switching system,

(c) enabling operation of said particular ones of said program blocks when a particular signalling signal is to be generated in the processing of a telephone call to or from the communication switching system, to match said particular protocol, whereby the communication switching system is enabled to process calls restricted to said particular protocol out of said plurality of protocols for a particular call.

2. A method as defined in claim 1, including generating the signalling signals in a universal signalling generator which is adapted to receive commands from the program blocks and to generate signalling signals in response thereto.

3. A method as defined in claim 1, including connecting the universal signalling generator to a trunk through a switch, and transmitting the signalling signals to the trunk via the switch for transmission to a remote communication switching office.

4. A method as defined in claim 3, including transmitting the signalling signals in a voiceband to the remote telephone switching office.

5. A method of interoffice signalling of a communication switching system comprising:

(a) storing program blocks for commanding operation, in a plurality of signalling protocols, of a signalling signal generator and signalling signal receiver;

(b) storing designation of particular ones of said program blocks which relate to a particular signalling protocol to be used by said system,

(c) enabling operation of only said particular ones of said program blocks during the processing of a call to or from said system, to command the signal generator to generate particular signals to be generated or to detect the receipt of particular signals received by said receiver,

whereby the communication switching system is enabled to process calls restricted to said particular protocol out of said plurality of protocols.

6. A method as defined in claim 5, including the steps of displaying a chart of signalling functions, receiving command data from an operator relating to particular signalling operations to be used by the system corresponding to said functions, and processing the command data to form said program block designations.

7. A method as defined in claim 6 including providing a signal generator and signal receiver which can respectively transmit and receive signalling signals in forms corresponding to all said

plurality of signalling signals, the signalling generator operating in response to said commands to generate signals only in accordance with said particular protocol.

8. A method as defined in claim 7 including connecting the signal generator and signal receiver to a trunk for transmitting and receiving signals via said trunk.

9. A method as defined in claim 8 in which the signalling signals are transmitted and received in voiceband via said trunk.

10. A method as defined in claim 9 in which said signals are pulse code modulated.

11. A communication switching system comprising:

(a) signal generating means for generating interoffice signalling signals,

(b) at least one trunk for transmitting the signalling signals,

(c) means for connecting the signal generating means to the trunk,

(d) means for storing a plurality of program blocks for commanding generation of the signalling signals according to a plurality of protocols,

(e) means for storing designations of particular ones of the program blocks to command operation of the signal generating means in accordance with a particular predetermined protocol,

(f) means for enabling said particular ones of the program blocks during the processing of a call to or from another switching office,

whereby communication therewith in accordance with said particular predetermined protocol is mandated.

12. A system as defined in claim 11, in which the means for storing said blocks and means for storing said designations is a peripheral processor memory adapted to transmit said particular ones of the program blocks to the signal generating means.

13. A system as defined in claim 12, in which the means for connecting the signal generating means to the trunk is a switch controlled by the peripheral processor.

14. A system as defined in claim 11 in which the signal generating means is comprised of a controller for receiving said particular ones of the program blocks and a signal generator controlled by the controller for generating said signals.

15. A system as defined in claim 14 in which said signal generating means includes a receiver for receiving signals from said another switching office, controlled by the controller.

16. A system as defined in claim 15 in which the means for connecting the generating means to the trunk is a time and/or space division switching matrix.

17. A system as defined in claim 16, in which the means for storing said blocks and means for storing said designations is a peripheral processor memory adapted to transmit said particular ones of the program blocks to the signal generating means.

18. A system as defined in claim 17 in which the switching matrix is controlled by the peripheral processor.

19. A system as defined in one of claims 11-14 including a system processor for controlling operation of said system and for generating a display, means for receiving data relating to signalling functions for predetermining said protocol in response to said display, means for generating said designations of particular ones of the program blocks, and for providing said designations to said means for storing said designations.

20. A system as defined in one of claims 11-14 including an operator input-output console, a system processor controlling operation of said system and console, means for generating a display on said console relating to signalling functions, means for receiving data input on the console relating to particular signals for predetermining said protocol in response to said display, the system processor including means for generating designations of particular ones of the program blocks corresponding to said data, and for providing said designations to said means for storing said designations.

21. A method of producing interoffice signalling as claimed in claim 1 substantially as described herein with reference to Figs. 1 to 3 and either Fig. 4 or Fig. 5 of the accompanying drawings.

22. A system as claimed in claim 11 including an arrangement substantially as described herein with reference to any one of the accompanying drawings.

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